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PC SWAT 2.0 (BETA VERSION): USERS MANUAL

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This is a user's manual for the beta version of PC SWAT 2.0. PC SWAT 2.0 is a high frequency sonar performance prediction model of the shallow water and very shallow water environment. Some of the enhancements of PC SWAT are a Windows-style Graphical Users Interface; improved environmental models, usually Applied Physics Laboratory/University of Washington Technical Report 8907 models; the inclusion of up to 3200 multipaths in the computation of surface and bottom reverberation; the ability to simulate real aperture, synthetic aperture, and constant resolution sonars; and the ability to place the target at a fixed depth of either a fixed bearing relative to the sonar or a fixed cross range (off axis) displacement relative to the sonar.

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FOREWORD

This report is a user's manual for the beta version of PC SWAT 2.0. PC SWAT 2.0 is a high frequency sonar performance prediction model of the shallow water and very shallow water environment.

The process of reporting bugs is to make a copy of the input files such as *pcswatm.in* and *svp.in* and FAX them, along with a detailed description of what you were doing when the error occurred, to (904) 234-4886. Alternatively, these items can be mailed to the following address.

Attn: Code 130B (Sammelmann)
Commanding Officer
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User comments on the beta version of PC SWAT are solicited. Comments should be mailed to the same address for reporting bugs. It is hoped a distribution version of PC SWAT will be made available after all user comments have been tallied and a satisfactory product is available.

PC SWAT was sponsored by the Office of Naval Research, Code 321. The author would like to acknowledge the helpful comments from John Lathrop and James Christoff, and Victor Johnson and Richard Holtzapple for performing extensive beta testing of PC SWAT.

Approved by:

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INTRODUCTION

PC SWAT 2.0 is a high frequency sonar performance model for the shallow water and very shallow water regime. Some of the features of PC SWAT are improved environmental models (typically Applied Physics Laboratory/University of Washington (APL/UW)) Technical Report (TR) 8907 models); bottom loss (APL/UW TR 8907); inclusion of up to 3200 multipaths in the computation of surface and bottom reverberation; three-dimensional beam patterns; user-friendly Graphical Users Interface (GUI); the ability to simulate real aperture, synthetic aperture, and constant resolution sonars; graphics; the ability to place the target at a fixed depth; and either a fixed bearing or cross range (off axis) relative to the sonar.

The minimum computer requirements for PC SWAT are a 386 DX with 8 MB of ram and 20 MB of disk space. PC SWAT will run on a personal computer (PC) with as little as 4 MB of ram, but there will be a slight degradation in performance as the program uses virtual memory to replace ram. PC SWAT will also run on a 486 SX. However, the simulation will be much slower than a 486 DX.

PC SWAT is a multiplatform simulation with a GUI as a front end to the simulation. The operation of the GUI should be familiar to anyone acquainted with Windows applications. The GUI uses accelerator keys and mouse behavior generic to all Windows applications. In addition, PC SWAT has a context sensitive help system and an error system.

The GUI is written in Symantec C++ 6.1 using Zinc Applications Framework 3.6. The actual simulations are written in FORTRAN using Powerstation. The advantages of this combination are that it optimizes speed and flexibility and makes it relatively painless to port PC SWAT to other operating systems such as Windows OS/2, Windows NT, or Motif.

PC SWAT is an energy model designed to predict signal-to-noise ratios (SNRs) and reverberation levels for sonars. This model assumes the projector and receiver are collocated. A coherent edition of PC SWAT is the SWAT imaging simulation, which produces coherent images of volume, proud, and partially buried mines. A beta version of the imaging simulation is scheduled for release sometime during fiscal year 1995. The imaging simulation will require the equivalent of a DEC AXP PC with 32 MB of memory.

INSTALLATION

To install PC SWAT, type the command **md c \swat** at the DOS prompt to make the directory to contain PC SWAT. Note, if you wish to use some other directory to hold PC SWAT either skip this step if the directory already exists or substitute the corresponding directory name for **c \swat.**

Next, place the disk containing PC SWAT into a (b) drive and type the command **copy a *.* c \swat** at the DOS prompt. Repeat this procedure for each disk in the package.

The file **pczip.exe** is a self-extracting zip file. Type the command **pczip.exe** at the DOS command prompt. This action uncompresses the files in **pczip.exe.**

The file **pcuser.eps** is a color postscript file containing a copy of the users manual for PC SWAT.

The section GETTING STARTED is an introduction on how to run PC SWAT. The section TEST CASE contains a test case you can run to test the installation of PC SWAT.

GETTING STARTED

To start PC SWAT, go to the directory containing PC SWAT and type **pcswat** at the DOS prompt.

To obtain general help and instructions on running PC SWAT, select the menu item **Help\Contents** from the menu in the **Main** window. Select the topic you wish help on and press **F1**. Remember, the key combination **Alt+F4** closes the **Help** window.

To use PC SWAT, you must first create a file with the desired input parameters and then save this file. The input parameters of PC SWAT are accessed through the menu items **Sonar**, **Target**, **Environment**, and **Multipaths**. Properties of the sonar are accessed through the **Sonar** menu item. Properties of the target are accessed by the **Target** menu item. Environmental attributes are accessed by the **Environment** menu, and the number of multipaths and maximum range are accessed by the **Multipaths** menu.

You must also create a sound velocity profile using either the menu items **SVP/New**, **SVP/OPEN**, or **Run/SVP** and then save this file.

To run the SNR simulation, you must select the **Run/SNR** menu item and click on the **OK** button. If you have failed to save input parameters to a file, PC SWAT will then prompt you if you wish to save the current input parameters. After making this choice, you will be returned to the original window. If you wish to proceed with the simulation, you should click on the **OK** button. If you wish to abort the simulation, you can click on the **CANCEL** button.

To plot the SNR and reverberation parameters on the screen, you can select the menu item **Plot/SNR**, which will prompt you for which parameters contained in the file **pcswatm.out** you wish to view. Note that multiple items can be selected in this window.

To make a log file of the input parameters and a copy of the output file **pcswatm.out**, you can select the menu item **Log/Log**, which saves the log file and output file to a user-specified file. The format of all output files created by PC SWAT is described later in this report.

PC SWAT also contains an error system. If you input a value for one of the input parameters outside a given range, PC SWAT will respond by displaying an error window specifying the range of values PC SWAT will accept.

The error system cannot catch all errors, particularly those errors associated with the sound velocity profile and the remaining input parameters, since the GUI cannot determine what the final values for the input parameters and sound velocity profile are until you decide to run the SNR simulation. In this case, the simulation **pcswatm.exe** performs a final check of the input parameters and sound velocity profile to see if they are consistent. If **pcswatm.exe** determines there is an inconsistency between the sound velocity profile and the input parameters, it will abort and display an error message on the screen. You can return to the GUI by pressing the **ENTER** key, and you have the option of correcting the problem that caused the error.

INPUT PARAMETERS

As a note on units, be advised PC SWAT uses the following conventions.

	Units
Length (Distance)	meters (m)
Angle	degrees (deg)
Time	milliseconds (msec)
Sound Velocity	kilometers/second (km/sec)
Wind Speed	knots (kn)
Pressure	decibels/micropascal (dB/µPa)
Sidelobe Level	decibels (dB)
Salinity	parts per thousand (ppt)
Temperature	Celsius (°C)
Frequency	kilohertz (kHz)

All the input parameters to the SNR simulation are contained in the two ASCII files **pcswatm.in** and **svp.in**. The file **svp.in** contains the sound velocity profile to be used in the simulation. The file **pcswatm.in** contains the remaining input parameters. This section describes the input parameters in the file **pcswatm.in**. Creating and importing a sound velocity profile is discussed in the next section.

If you wish to use the input parameters stored in a file other than **pcswatm.in**, you must first open this file and then save it. This operation will save the file to **pcswatm.in**.

The input parameters contained in the file **pcswatm.in** are controlled by the menu items **Sonar**, **Target**, **Environment**, and **Multipaths**.

To create a new file, select the menu item **File/New** from the main menu. The name you specify in the associated window is the name under which the input parameters will be saved. Note that PC SWAT automatically initializes the input parameters and assumes you are creating a new input file.

To open or modify an existing input file created by PC SWAT, select the menu item **File/Open** from the main menu and enter the name of the file in the associated window.

If you wish to save the current settings of the input parameters to a user-specified file, you must select either the **File/Save** or **File/Save As** menu items from the main menu. PC SWAT will save the input to your specified file and the file **pcswatm.in**. The reason PC SWAT saves the input parameters to the file **pcswatm.in** is that PC SWAT always uses the values of the file **pcswatm.in** when calculating the SNR.

If you make any changes to the input parameters and forget to save these parameters before you decide to run the SNR calculation, PC SWAT will display a window informing you that you have not saved your most recent modifications and it will prompt you as to whether or not you wish to save these parameters. If you choose to save these parameters, they will be saved to the file **pcswatm.in**, which serves as input to the SNR simulation. To save the contents to another file, select the menu item **File/Save As**.

The menu item **Sonar** describes the properties of the sonar such as source level, frequency, beam width, etc. The majority of sonar parameters are accessed by the menu item **Sonar/Projector**. This menu item activates a window that contains items for the source level, frequency, band width, pulse length, depression angle of the projector, type of sonar, and how you wish to specify the horizontal and vertical beam patterns of the projector.

Enter the source level of the projector in decibels. Typical values of the source level range between 200 and 240 dB. Enter the frequency in kilohertz. Enter the band width in kilohertz. Enter the pulse length in milliseconds. Enter the depression angle of the projector in degrees. Note that negative depression angles point downward and positive depression angles point upward. Enter the depth of the sonar in meters.

Depending upon whether you specified the enter length option, you should either enter the length of the projector in meters or the beam width of the projector in degrees. Below this item is an item specifying the sidelobe level of the beam pattern in decibels. A selection of 13 for this item means the sidelobe is 13 dB smaller than the main beam. The sidelobe level of a sonar depends upon the shape and weighting of the array. A uniformly weighted array has a sidelobe level of 13. A Hamming weighted array has a sidelobe level of 41. Note that decreasing the sidelobe level also broadens the main beam for an array of fixed length. Note that PC SWAT assumes the beam pattern for both the projector and the receiver are equal to the farfield beam patterns.

You have the option of selecting either a real (conventional) aperture, constant resolution, or synthetic aperture sonar. The main difference between these three types of sonars is their cross range (off axis) resolution as a function of range. The real aperture sonar option assumes the sonar is operating in the farfield, where the cross range resolution is given by the expression **(horizontal beam width in radians)(range).** The constant resolution sonar assumes the sonar is operating in the near field, and the cross range resolution is constant. The synthetic aperture sonar option also assumes the cross range resolution is constant.

You have the option of entering either the length and height of the array or the horizontal and vertical beam width of the array.

If you specified the real aperture option, a window will appear that lists the options **No Matched Filter Processing** and **Matched Filter Processing**. These two options determine how the range resolution of the sonar is computed. The **No Matched Filter Processing** option assumes the range resolution of the sonar is given by the expression **(speed of sound)(pulse length)/2**.

The **Matched Filter Processing** option assumes the receiver has a processing gain of **10 log((Band Width)(Pulse Length))**, which translates into a range resolution given by the expression **(speed of sound)/2/(band width).**

If you specified either the constant resolution or synthetic aperture sonar options, a window appears that allows you to specify both the range resolution and the cross range resolution of the sonar in meters.

The menu item **Sonar/Receiver** allows you to access the beam pattern of the receiver. This window contains items for the number of vertical beams, the depression angle of the receiver, and the beam width and sidelobe levels of the receiver. PC SWAT allows the receiver to have multiple identical vertical beams. These beams are symmetrically placed around the depression angle of the receiver, with an angular separation equal to the vertical beam width of each beam. Enter the depression angle in degrees, remembering that a negative depression angle represents a downward pointing beam and a positive depression angle represents an upward pointing beam.

Finally, select whether you wish to input the linear dimensions of the array or the horizontal and vertical beam widths. If you select the **Enter Length** option, you must enter the length (height) of the array in meters. If you did not select the **Enter Length** option, you must enter the beam width in degrees. Below this item is an item specifying the sidelobe level of the beam pattern in decibels.

The menu item **Target** allows you to specify the target strength and position of the target relative to the sonar. The first window contains an item for the target strength of the target in decibels and an item for the depth of the target. This window also allows you to select whether you wish the target to be kept at a fixed bearing as a function of range or at a fixed cross range displacement. If you select the constant bearing option, you must enter the bearing of the target in degrees. If you select the constant cross range option, you must enter the off axis displacement of the target in meters.

The menu item **Environment** allows you to access the environmental information such as wind speed, bottom type, temperature, and salinity.

The menu item **Environment/Bottom** allows you to specify the bottom type. This window contains a **READ** button and a combo box. To view the current bottom, click on the **READ** button. This initializes the current selection in the combo box. To change bottom types, click on the button on the right-hand side of the combo box and a vertical list with vertical scroll bars will appear. You have the option of choosing one of the 18 different bottom types discussed in TR 8907. Simply click on the desired bottom type and click on the **OK** button to set the bottom type.

The menu item **Environment/Misc** contains items for surface reverberation, volume reverberation, ambient noise, and absorption. This window contains the following items: wind speed, density of marine life, temperature, salinity, and pH. Enter the wind speed in knots (1 kn is approximately 0.5 m/sec). The wind speed is used to determine the surface scattering strength and ambient noise. Enter the density of marine life: **1** for sparse, **2** for medium, and **3** for dense marine life. Enter the temperature in degrees Celsius. Enter the salinity in parts per thousand. Note the salinity of sea water is approximately 35 ppt. Enter the pH (1–14). The pH of sea water is approximately 8. The temperature, salinity, and pH are used to determine the absorption coefficient.

PC SWAT uses APL/UW's volume scattering and absorption models documented in TR 8907. PC SWAT uses APL/UW's surface scattering model documented in a pre-released version of TR 9407. This model should be regarded as work in progress, and it will be updated as soon as APL/UW finalizes this model. This model includes attenuation and reverberation due to bubbles. However, this model has not been validated above approximately 45 kHz. Thus, the extrapolations made from lower frequencies and lower wind speeds may lead to an over prediction of surface bubble loss at higher wind speeds and higher frequencies.

The menu item **Multipaths...** contains miscellaneous input parameters not found in the other three menu items. Selecting this menu item displays a window with three items.

The first item in this window is the number of bounces to include in the simulation. Because of the way PC SWAT organizes multipaths into paths with different numbers of bounces, the actual number of different multipaths used in the simulation is given by the expression **8 (number of bounces)(number of bounces).** Thus, setting the number of bounces to 5 represents 200 multipaths. The number of bounces required for convergence varies with water depth, range, and the beam width of the sonar. The recommended number of bounces is given by an expression of the form **(number of bounces)=(maximum range)/(water depth)/4** for sonars with broad vertical beams. For sonars with narrow vertical beams, the number of bounces required for convergence is less.

The second item in the window is the maximum range at which to compute the SNR. The increment between adjacent points in the SNR calculation is determined by the range resolution of the sonar.

The third and final item in this window is the detection threshold in decibels. When PC SWAT calculates the SNR, it will look for that signal-to-noise level above the detection threshold with maximum range. This range and the corresponding SNR are displayed on the screen after completion of the SNR calculation. This enables you to quickly determine the maximum detection range for a given set of parameters.

SOUND VELOCITY PROFILE

You have the option of either creating your own sound velocity profile or importing a sound velocity profile into PC SWAT.

The format of a sound velocity profile acceptable to PC SWAT is as follows: First, the sound velocity must exist in an ASCII file with two columns of numbers. The first column is depth in meters and the second column is the sound velocity in kilometers per second. The depth of the first point in the sound velocity profile must be zero, representing the sound velocity at the surface. The last point in the sound velocity profile must equal the water depth, representing the sound velocity at the bottom. If you use scientific notation in the sound velocity profile, you must use the **e** format for the exponent, since PC SWAT uses **C fscanf** function to read the sound velocity profile.

If you wish to import a sound velocity profile into PC SWAT, you must first read the file using the menu item **SVP/Open** and save the file using either the menu item **SVP/Save** or **SVP/Save As**. This procedure imports the sound velocity profile into PC SWAT and saves it to the file **svp.in**.

If you wish to create a synthetic sound velocity profile from within PC SWAT, there are two methods available to you. The simplest method is to go to the menu item **Run/SVP** and select this menu item. You will be prompted for the water depth and various other parameters. This option generates a synthetic sound velocity profile by fitting the sound velocity profile to a quadratic equation whose coefficients are specified by you. This option computes the sound velocity profile and saves it to the file **svp.in**. The second method available to you is to select the menu item **SVP/New**. This menu item will bring up a window prompting you for the file name of the new sound velocity profile. After you have specified a file name for the new sound velocity profile, a window will appear that allows you to input the depth and sound velocity of the profile. Depth should be entered in meters, and sound velocity should be entered in kilometers per second.

If you select the menu item **SVP/Open**, you will be prompted for the file name of the sound velocity profile. If the file containing the sound velocity profile is successfully opened and read, a window will appear that will allow you to edit the sound velocity profile. If you do not wish to modify the sound velocity profile, click on the **OK** button and the sound velocity profile will be saved to the file **svp.in**.

The window that allows you to edit the sound velocity profile contains 3 buttons, 19 boxes, and a menu. The menu contains the items **Next**, **Previous**, **Add**, **Delete**, **Insert**, and **Modify**. The window contains space for six points in the sound velocity profile. The left most column contains the point number in the sound velocity profile. A value of zero in this column signifies that the point representing this row does not belong to the sound velocity profile. The middle column contains the depth of the point in meters. The right-most column contains the sound velocity of the point in kilometers per second.

To initialize the six points with data from the sound velocity profile currently in memory, if any, click on the **READ** button. To display the next point in the sound velocity profile, click on the **Next** menu item. To display the previous point in the sound velocity profile, click on the **Previous** menu item. To add a point at the end of the sound velocity, move to the end of the sound velocity and enter the depth and sound velocity in the first row that has zero in the left column, then click on the **Add** menu item. To insert a point in between two points in the sound velocity profile, move to the position where you wish to insert the point and enter the point number at which you wish to insert the point in the **Selected Point** box, then click on the **Insert** menu item. To delete a point from the sound velocity profile, first display the point and enter its point number in the **Selected Point** box, then click on the **Delete** menu item. To change or modify a point in the sound velocity profile, display the point, make the desired changes to the depth and sound velocity of this point, then enter its point number in the **Selected Point** box and click on the **Modify** menu item. When you are finished with the sound velocity profile, click on the **OK** button. This action will save the sound velocity profile to the file **svp.in**.

RUN MENU ITEM

This menu item allows you to run the various simulations that are the *heart* of PC SWAT. This menu item contains the items **SNR, SVP, Beam Patterns**, and **Ray Trace.**

The **Run/SNR** menu item allows you to run that part of PC SWAT that calculates SNRs and reverberation levels. When you select this menu item, a window will appear that contains a **View Input** button, **Plot SVP** button, an **OK** button, and a **CANCEL** button.

The **View Input** button allows you to view the input parameters currently in memory. If you click on this button, a window will appear with a **READ** button and a vertical list. You must click on the **READ** button to display the input parameters. You are then free to scroll through the vertical list. When you are finished perusing the input parameters, click on the **CLOSE** button. This will return you to the original window.

If you click on the **Plot SVP** button, the sound velocity profile within the file **svp.in** is plotted. When you are finished viewing the sound velocity profile, hit the enter key to return to the original window. If you click on the **CANCEL** button, the simulation is aborted. If you click on the **OK** button, PC SWAT checks to see if you have saved your latest changes to the input parameters. If not, a window appears that asks you if you wish to save these input parameters to the file **pcswatm.in**. If you click on the **SAVE** button, these parameters are saved and you are returned to the original window. If you click on the **CANCEL** button, these parameters are not saved and you are returned to the original window. If you still wish to run the simulation, click on the **OK** button, which will run the simulation. If you wish to abort the simulation, click on the **CANCEL** button. The contents of **pcswatm.in** can be plotted using the **Plot/SNR** item.

The **Run/SVP** menu item allows you to generate a synthetic sound velocity profile based upon a user-specified quadratic equation. When you select this item, a window appears with boxes for the depth of the ocean and the coefficients of the quadratic equation. The quadratic equation the simulation uses to fit the sound velocity profile is of the form **v = v0 + v1 dz + v2 dz**2**.

The coefficient **v0** is the sound velocity in the middle of the water column in meters per second. The parameter **dz** is the vertical distance from the midpoint of the water column. The coefficient **v1** is measured in meters per second per meter. The quadratic coefficient **v2** is measured in meters per second per meter per meter. If you click on the **OK** button, PC SWAT generates the sound velocity profile and saves it in the file **svp.in**. This file can be plotted using the **Plot/SVP** item.

The **Run/Beam Patterns** menu item creates the horizontal and vertical beam patterns of the projector and receiver parameters stored in **pcswatm.in**. This simulation stores these beam patterns in the four files **hprj.out**, **vprj.out**, **hrec.out**, and **vrec.out**. These files are also created every time you run the SNR simulation. These files can be plotted using the **Plot/Beam Patterns** items.

The **Run/Ray Trace** menu item creates a collection of ray trajectories for the sound velocity profile in the file **svp.in.** If you select this item, a window appears that allows you to specify the number of ray trajectories to create the depth of the sonar, the maximum range out to which the rays are to be traced, and the maximum launch angle of the rays. These ray trajectories are stored in the ASCII file **swtrace.out.** This file is plotted using the **Plot/Ray Trace** item.

PLOT MENU ITEM

This menu item allows you to plot the output of the **Run** menu items to the screen. In future editions of PC SWAT, this item will provide printer support and improved graphics.

The **Plot/SNR** item plots the output of **Run/SNR**. If you select this item, a window appears that contains checkboxes for the five different outputs contained in the file **pcswatm.out**. You can select multiple items to be plotted on a single graph. Once you have finished selecting the items you wish to plot, click on the **PLOT** button.

The **Plot/SVP** item plots the sound velocity profile in the file **svp.in**.

The **Plot/Beam Patterns** plots the beam patterns stored in the files **hprj.out**, **vprj.out**, **hrec.out**, and **vrec.out**. If you select this item, a window appears that allows you to select which beam pattern you wish to plot.

The **Plot/Ray Trace** plots the ray trajectories stored in the file **swtrace.out**.

LOG MENU ITEM

This menu item allows you to save and view input parameters.

The **Log/Log** item saves the contents of the file **pcswatm.out** to a user-specified file. This item also creates an annotated version of the files **pcswatm.in** and **svp.in** used to create this output file. This item was added to PC SWAT so that users could catalog input and output parameters.

The **Log/View** item allows you to view the contents of the input parameters currently in memory.

The **Log/Read** item is similar to the **Log/View** item with the exception that this item displays the input parameters in the current **pcswatm.in** file. Note that this item does not alter the contents of the parameters in memory.

HELP MENU ITEM

This menu item gives you access to general help on PC SWAT. Specific help on a particular window can be obtained by pressing **F1**.

The **Help/Help** item explains how to use the help system.

The **Help/Contents** item allows you to use a wide variety of help topics. If you select this item, a window will appear that contains a number of radio buttons. You can select the topic of interest and press **Fl** to display help on this topic. To close the help window, you can either access the system button or press the key combination **Alt+F4**.

The **Help/About** item contains acknowledgements about PC SWAT.

OUTPUT FILES

The main output file of PC SWAT is the file **pcswatm.out**. This file is an ASCII file consisting of six columns. The first column is horizontal range in meters. The second column is SNR in decibels. The third column is total reverberation **(surface + bottom + volume)** in decibel per micropascal. The fourth column is surface reverberation. The fifth column is bottom reverberation. The sixth column is volume reverberation.

The format of the file **svp.in** is described in the section on sound velocity.

The files **hprj.out**, **vprj.out**, **hrec.out**, and **hrec.out** contain the horizontal and vertical beam patterns of the projector and receiver. These files consist of two columns. The first column is the angle in degrees. The second column is the magnitude of the beam pattern in decibels.

The file **swtrace.out** is an ASCII file that contains the ray trajectories created by PC SWAT. The first item in this file is an integer representing the number of rays contained in the file. The succeeding items in the file are the individual ray trajectories. Each ray trajectory consists of an integer specifying the number of points in the trajectory. Following this integer are two columns representing the range and depth of each point in the ray trajectory. The first column is the range of the point in meters. The second column is the depth of the point in meters. This pattern is repeated for each ray trajectory stored within the file.

PLANS FOR FUTURE VERSIONS OF PC SWAT

This section outlines tentative plans for future versions of PC SWAT. These plans may change because of funding levels, user interest, and time constraints.

The plotting routines used in PC SWAT were written using plotting primitives found in Microsofts FORTRAN Powerstation. There are plans to update these routines with professional two-dimensional plotting routines. In addition, there currently exists no method of dumping a plot to a printer or a file. There are plans to add printer support to PC SWAT. Most likely printer support will be given for both monochrome and color postscript printers. Additional printers may be supported based upon user comments and the flexibility of the plotting routines.

There are plans to include bistatic surface and bottom reverberation models. In addition, there are plans to include an improved volume reverberation model. Currently, PC SWAT assumes no forward surface loss. Once a satisfactory surface loss model has been validated, there are plans to incorporate it into PC SWAT. Here it is important to distinguish loss from bistatic scattering. Loss represents attenuation of the field, whereas bistatic scattering redirects the energy, which may return to the receiver through some multipath arrangement.

The Acoustics Modeling Task has developed a coherent target strength model of mines that calculates the scattered pressure as a function of frequency, aspect angle and arrival time. This model has been validated on various targets in the frequency range 10–640 kHz with a typical error of 1 or 2 dB. Currently, there are plans to include the target strength model in PC SWAT. You will have the option of calculating the target strength for a finite cylinder with flat end caps, a finite cylinder with hemispherical end caps, a truncated one, and a prolate spheroid. You will be able to specify the size and shape of these targets. This will enable you to make more meaningful calculations of the probability of detection of a given target. It is planned that you will be able to specify a particular target, and PC SWAT will generate a curve representing the maximum detection range versus percentage target strength.

There are plans to add a column to the file **pcswatm.out** containing shadow depth as a function of range. By shadow depth, we mean the ratio of all reverberation (including the direct path from the bottom) to all reverberation except the direct path from the bottom.

TEST CASE

This section describes the test case included with PC SWAT.

The test case computes the SNR for a 20-kHz sonar with a 5-deg horizontal beam width and 20-deg vertical beam width projector and receiver in 20 m of water against a proud target. The sonar is at a depth of 10 m, with a depression angle of -10 deg. The maximum detection range of this sonar is approximately 84 m for a +12-dB detection threshold.

To run this case, first open the file **pctest.in** from the menu item **File/Open**. Next save this file in **pcswatm.in** by clicking on the **OK** button from the **File/Save As** menu item. Second, open the file **svptest.in** in the **SVP/Open** menu item and click on the **OK** button. This loads the sound velocity profile into the file **svp.in**. Third, choose **SNR** from the **Run** menu and click on the **OK** button. This will run the simulation.

To plot the SNR and reverberation, choose **SNR** from the **Plot** menu. Click on **SNR** to select the SNR, click on the **Plot** button to plot the SNR, and compare with the SNR plot In Figure 1. To plot reverberation, click on **SNR** to unselect this item. Next click on **Total**, **Surface**, **Bottom**, and **Volume**. Then click on the **Plot** button to plot them, and compare with the reverberation plot in Figure 2.

The file **pctest.log** contains a log file of the test case, and the file **pctest.out** contains a copy of **pcswatm.in** for the test case.

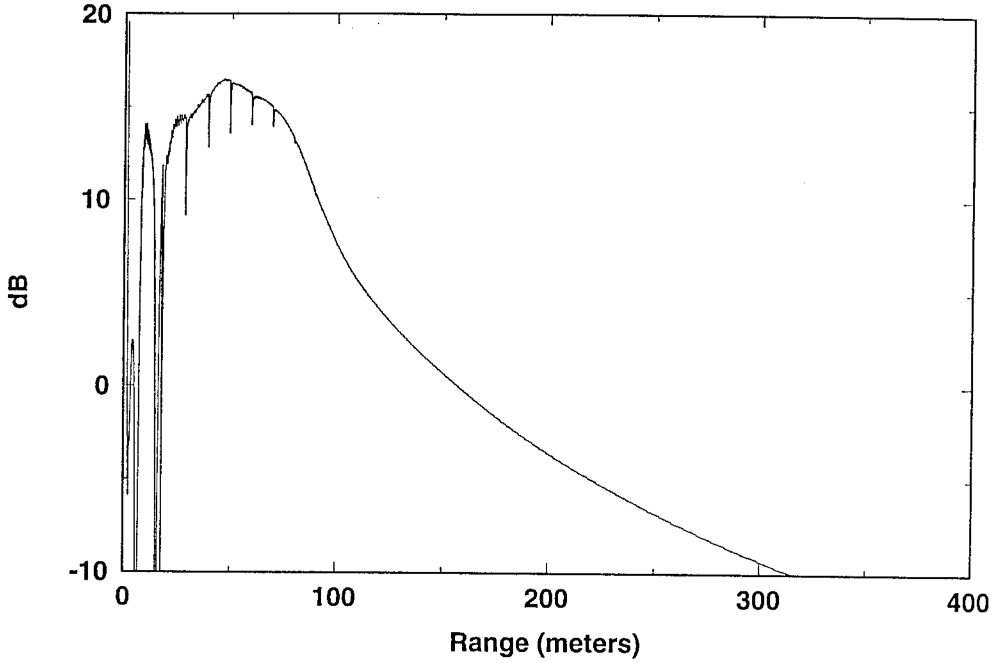

FIGURE 1. SNR PLOT

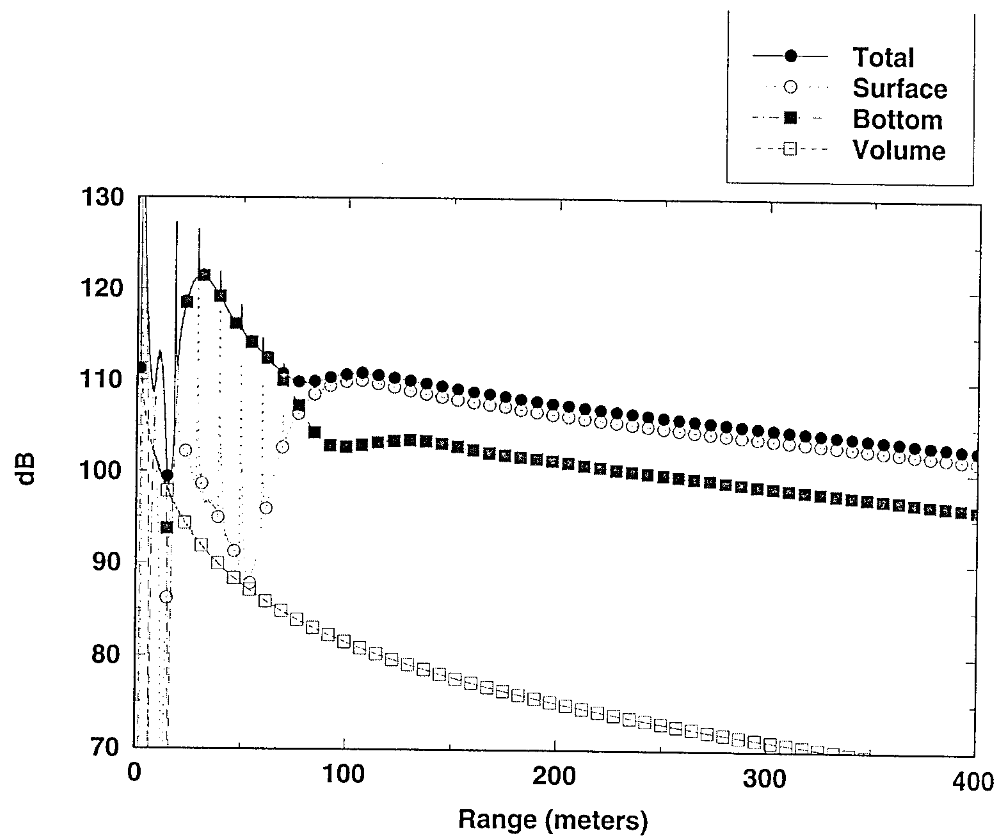

FIGURE 2. REVERBERATION PLOT

PC SWAT VALIDATION

PC SWAT has been shown to give results essentially identical to SEARAY and other widely used sonar models when common environmental models are used and the multipathing can be ignored. Thus, in non-multipathing environments, SWAT is as well validated as these other models. In multipathing environments, total reverberation predictions of PC SWAT show excellent agreement with experiments in all cases tried to date, but the number of these cases is small and validation efforts for multipathing environments will continue.

PC SWAT uses environmental models described in APL/UW TRs 8907 and 9407, which are generally regarded as the best available environmental models. While these models are assumed to be valid up to frequencies of several hundred kilohertz, most of these models have only been validated in the frequency range 10–100 kHz. In addition, neither the surface nor bottom reverberation models implemented in this version of PC SWAT explicitly model bistatic reverberation, which is needed for modeling of the contributions of multipaths to reverberation. PC SWAT provides the needed bistatic reverberation modeling by approximating the bistatic backscattering strength for both the surface and the bottom as the average of the backscattering strength at the incident and outgoing angles.

REPORTING BUGS

The process for reporting bugs is to make a copy of the input files such as **pcswatm.in** and **svp.in** and FAX them, along with a detailed description of what you were doing when the error occurred, to (904) 234-4886. Alternatively, you can mail these items to the following address.

Attn: Code 130B (Sammelmann)
Commanding Officer
CSSDD NSWC
6703 W. Highway 98
Panama City, Florida 32407 7001

REPORTING USER COMMENTS

User comments on the beta version of PC SWAT are solicited. Comments should be mailed to the same address for reporting bugs. It is hoped a distribution version of PC SWAT will be made available after all user comments have been tallied and a satisfactory product is available.

DISTRIBUTION

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